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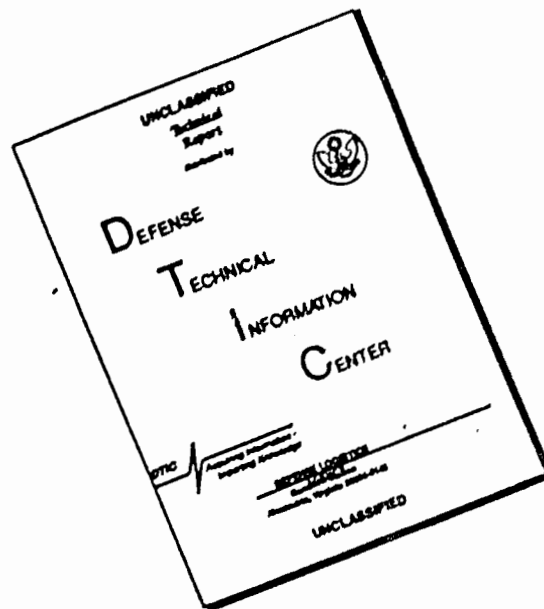
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U. S. A R M Y

TRANSPORTATION RESEARCH COMMAND

FORT EUSTIS, VIRGINIA

TCREC TECHNICAL REPORT 61-92

NOISE SURVEY HU-1A HELICOPTER  
WITH MODIFIED EXHAUST SYSTEM

Task 9R38-01-017-54

Contract DA 44-177-TC-562

July 1961



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prepared by :

VERTOL DIVISION  
THE BOEING COMPANY  
Morton, Pennsylvania



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Mr. J. E. Forehand/bsb/22197

HEADQUARTERS  
U. S. ARMY TRANSPORTATION RESEARCH COMMAND  
TRANSPORTATION CORPS  
Fort Eustis, Virginia

TCREC-ADS 9R38-01-017-54

SUBJECT: Noise Survey HU 1A Helicopter with Modified Exhaust System

TO: See Distribution List


1. During the course of aircraft research or development programs, modifications are occasionally made which may affect the noise level of the aircraft.

2. A research program was recently conducted which resulted in a modified engine exhaust system for HU-1A helicopter number 9-1632. The purpose of the following report is to present a comparison of noise output of this helicopter with that of a similar helicopter in standard configuration.

3. The conclusions made by the contractor are concurred in by this Command.

4. This report is a supplement to TREC Technical Report 61-72 and is the first report of a continuing program to maintain up-to-date information on the internal and external noise levels of current and future Army aircraft. Additional reports of this type will be submitted as the data become available.

FOR THE COMMANDER:

Approved by:  
  
Everett Forehand  
Project Engineer

  
EARL A. WIRTH  
CWO-4 USA  
Adjutant

Task 9R38-01-017-54

Contract DA 44-177-TC-562

July 1961

NOISE SURVEY HU-1A HELICOPTER  
WITH MODIFIED EXHAUST SYSTEM

REPORT 247

Prepared By

VERTOL DIVISION

THE BOEING COMPANY

MORTON, PENNSYLVANIA

FOR

U. S. ARMY TRANSPORTATION RESEARCH COMMAND

FORT EUSTIS, VIRGINIA

## FOREWARD

This report was prepared by the Dynamics Department of Vertol Division of The Boeing Company, under Contract DA44-177-TC-562, Project 9R38-01-017-52, Amendment 4. It was funded by U. S. Army Transportation Research Command, and was under the technical cognizance of Mr. J. Everette Forehand, USA TRECOM, Ft. Eustis, Virginia.

Sound level tests were conducted at Hayes Aircraft Corporation, Birmingham, Alabama. Aircraft Project Engineer was Mr. J. Davenport. Mr. C. Shakespeare of Vertol supervised field measurements.



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## MODEL HU-1A

### CONCLUSIONS

Noise levels of Army HU-1A helicopters 9-1632 (equipped with a modified exhaust system) and 58-2080 (standard configuration) were recorded under similar operating and ambient conditions and are, therefore, directly comparable. Some difference exists in the 200 ft directivity patterns of the aircraft in hover, along with an increase in high frequency noise in take-off and landing. The latter may be due to various pilot techniques in achieving the requirements of Test 2. Except for these, however, sound pressure levels of the aircraft, under similar operating conditions, are considered the same. Other differences lie within the envelope of repeatability.

It is, therefore, concluded that the modified exhaust system of HU-1A No. 9-1632 does not significantly affect the acoustic characteristics of the aircraft.

## INTRODUCTION

A noise level survey of an Army HU-1A helicopter with a modified exhaust system (Ser. 9-1632) was made in conformance with tests and procedures reported in Reference 1. Data have been presented in a manner similar to Reference 1 and a comparison is made with HU-1A (Ser. 58-2080) noise levels reported therein.

The aircraft and operating conditions were similar, so that sound levels of the two aircraft may be directly compared. Gross weight, engine torque, gas generator rpm and rotor rpm have been compared and found to be similar in each instance.

## DISCUSSION

Figure 1 is an illustration of HU-1A S/N 9-1632. Measurement equipment is shown installed in the aircraft in Figure 2.

Sound levels of the HU-1A in hover are shown in Figure 4. A noticeable difference exists in the directivity pattern in the high frequencies (1200 - 2400 cps, 2400 - 4800 cps and 4800 - 10,000 cps octave bands) on the port side of the aircraft. The remaining differences, however, are not of real significance, and are felt to lie in the range of repeatability.

Take-off and landing noise is shown in Figure 6. No large differences are noted between aircraft except in the high frequency (2400 - 4800 cps and 4800 - 10,000 cps) bands where HU-1A Serial 9-1632 shows an increase (about 10 db) at locations 1 and 2.

Noise levels of the aircraft in flyby are plotted in Figures 8, 9 and 10. Again, no significant difference is noted.

Internal sound levels are plotted in Figures 12, 13 and 14. While sound pressure levels inside aircraft 9-1632 are less than aircraft 58-2080, this may be due to a difference in interior configurations of the aircraft. Aircraft 58-2080 contained an auxiliary, range-extension fuel tank which considerably altered the internal acoustics of the aircraft. As a result, sound levels inside the two aircraft are not directly comparable. Comparison plots of the two aircraft are presented for hover and overhead flyby conditions in Figures 18, 19 and 20, respectively. Each spectrum level in Figure 18 represents an average value of three locations. This was done so that no one point would indicate a false trend. Note that the aft locations for 9-1632 have a somewhat higher SPL. Finally, overhead flyby comparisons do not indicate any significant trend, although at the 500 ft. altitudes, 9-1632 does have a lower SPL.

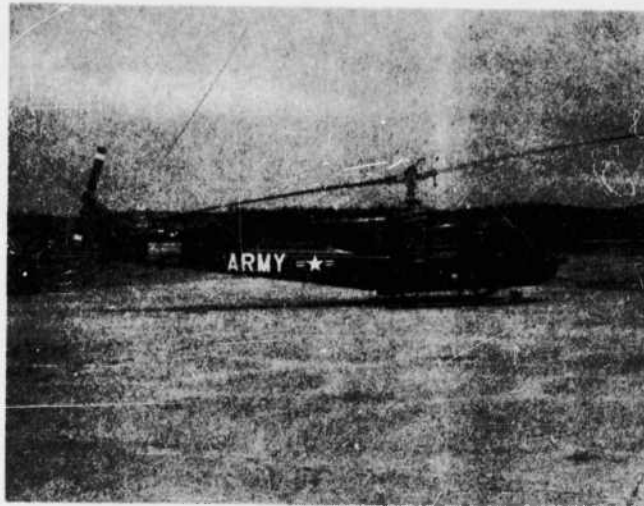
Figures 15, 16 and 17 are narrow band (continuous spectrum) charts which are directly comparable with those appearing in Reference 1.

Figure 21 is a comparison of fundamental frequencies and harmonics for each identifiable noise source at position 23, Test 1.

#### BIBLIOGRAPHY

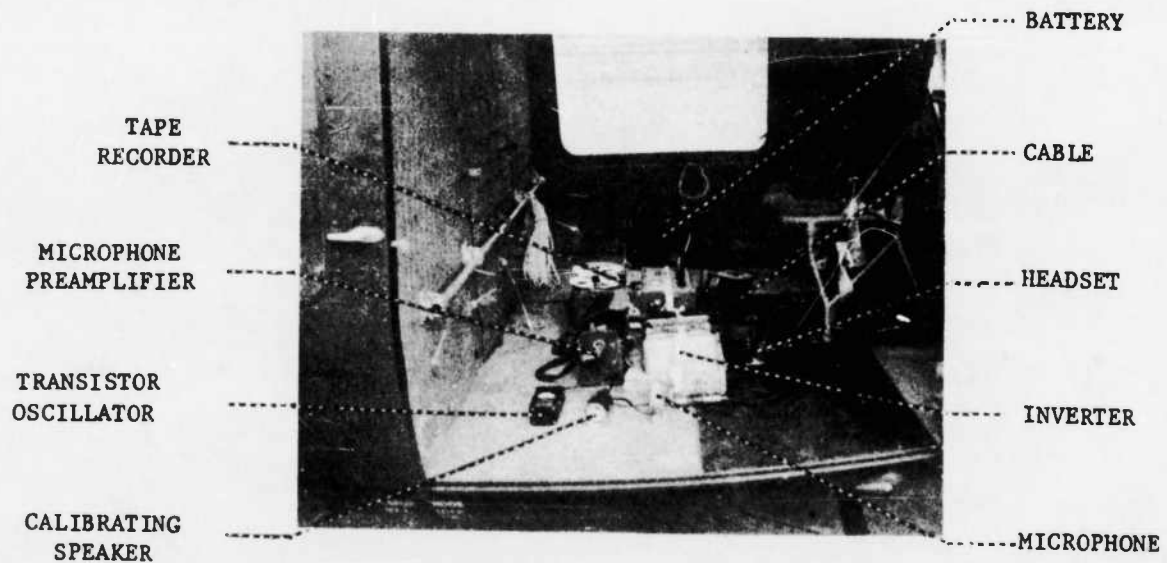
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Noise Reduction, L. L. Beranek, Ed., McGraw-Hill Book Co.,  
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McGraw-Hill Book Co., Inc., New York, 1957.

APPENDIX I  
ILLUSTRATIONS



HU-1A HELICOPTER  
S/N 91632

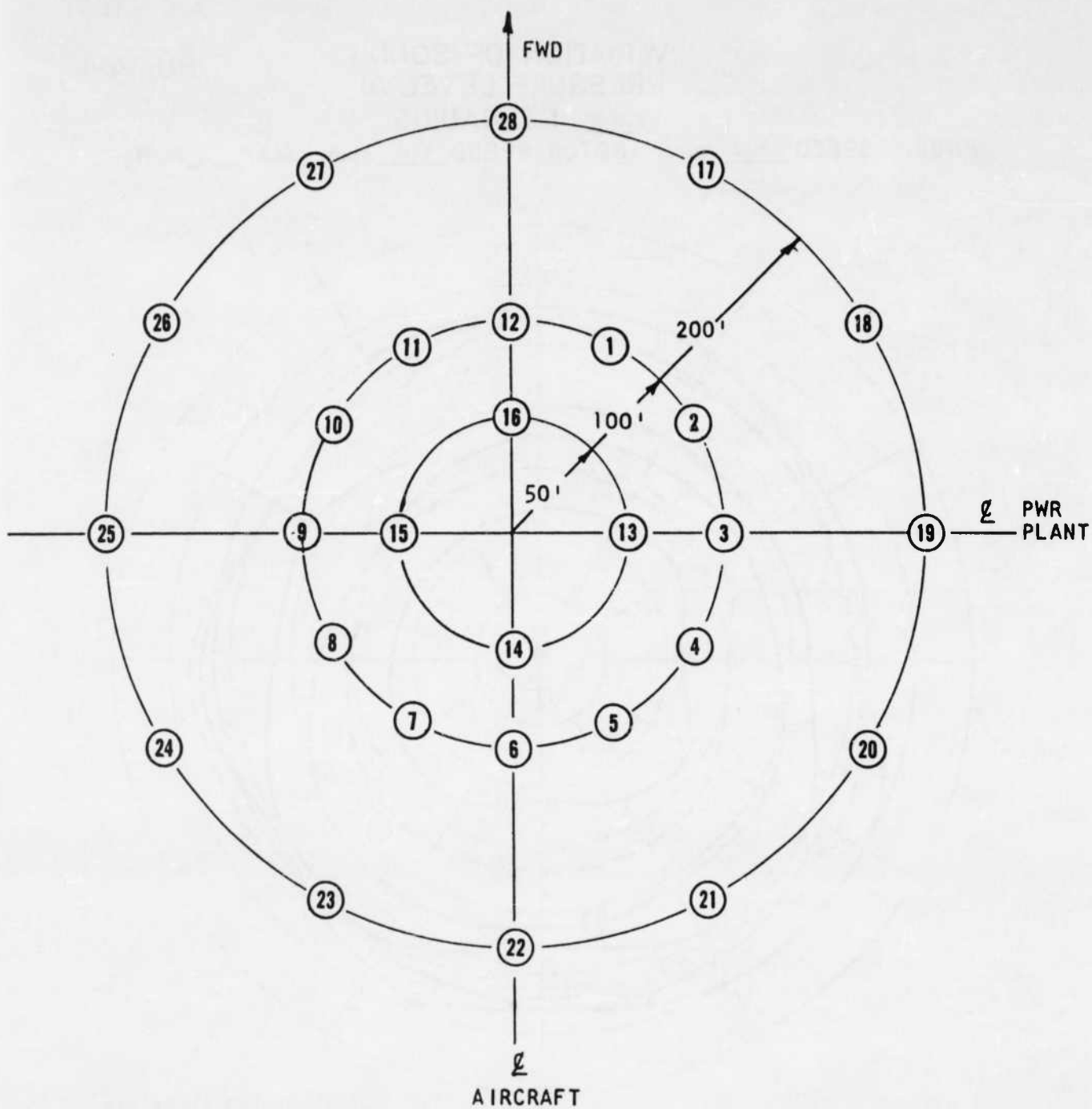
FIGURE 1



SOUND LEVEL RECORDING EQUIPMENT

FIGURE 2





MEASUREMENT LOCATIONS - TEST 1

FIGURE 3

A/C - TEST

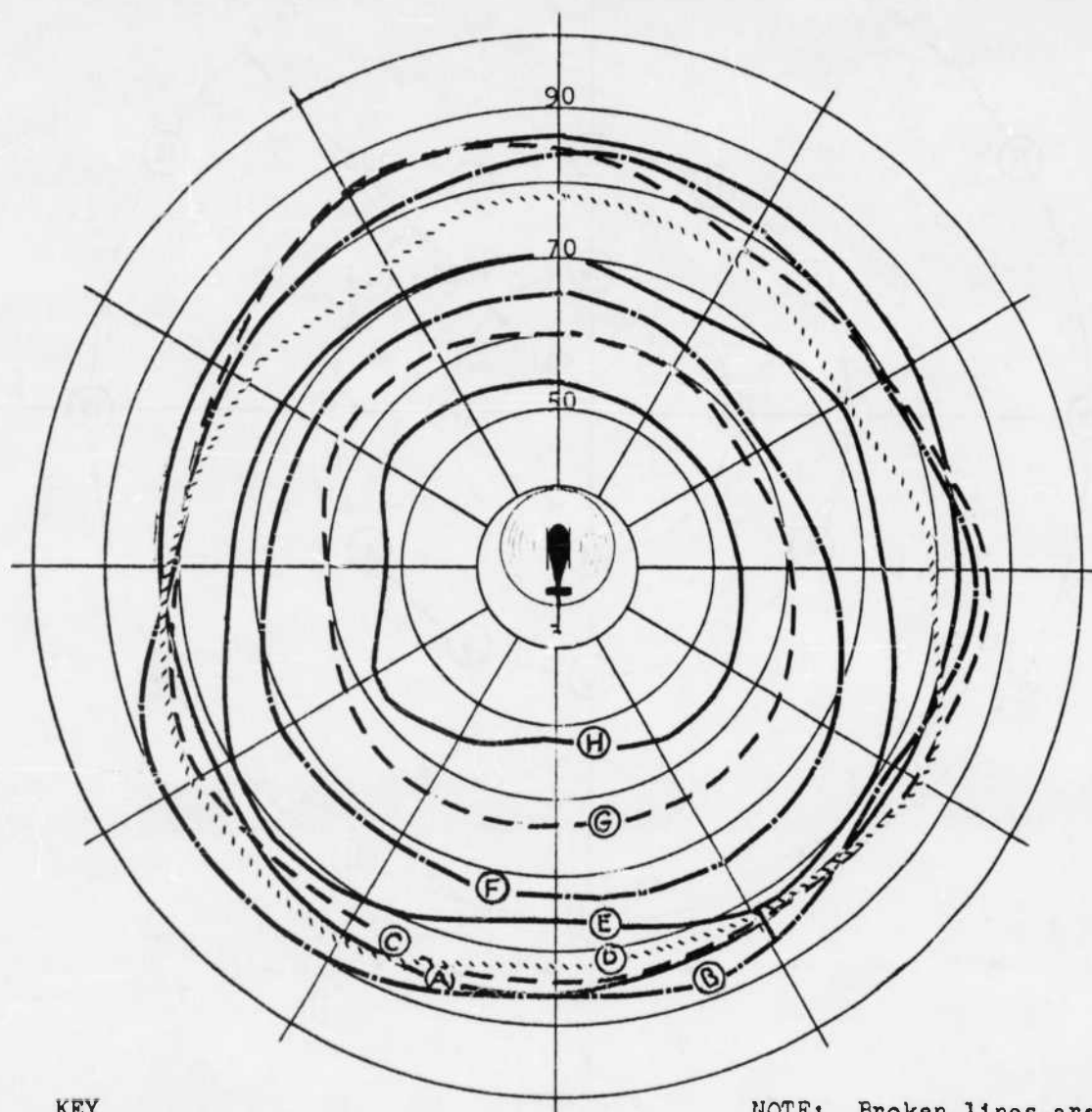
HU-1A-1

VARIATION OF SOUND  
PRESSURE LEVEL AT  
200 FT. RADIUS

ENGINE SPEED 6400 rpm

ROTOR SPEED 320 rpm

MAP      in. Hg

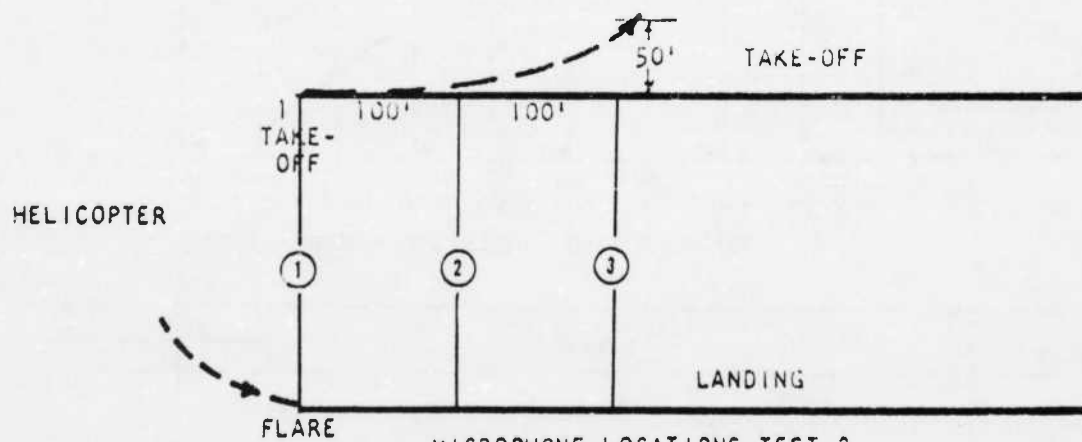
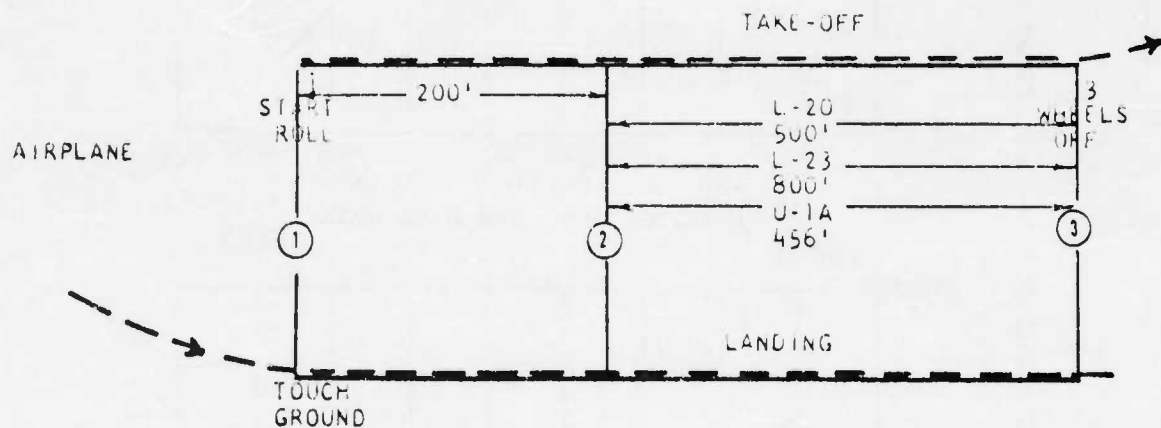
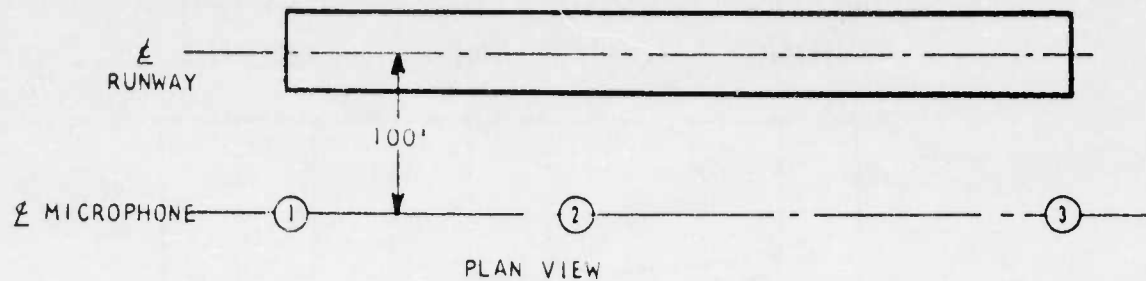


**KEY**

Symbol	Octave Band - CPS
A	20-75
B	75-150
C	150-300
D	300-600
E	600-1200
F	1200-2400
G	2400-4800
H	4800-10 KC

NOTE: Broken lines are  
for clarity only.

Figure 4



MICROPHONE LOCATIONS TEST 2

FIGURE 5

# MAXIMUM SOUND PRESSURE LEVELS DURING TAKEOFF AND/OR LANDING

SOUND PRESSURE LEVEL IN BAND ~ DECIBELS RE 0.0002 DYNE/CM<sup>2</sup>

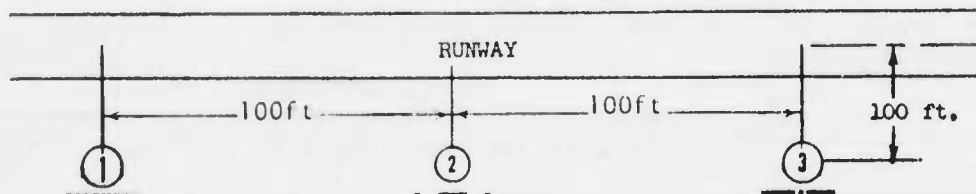
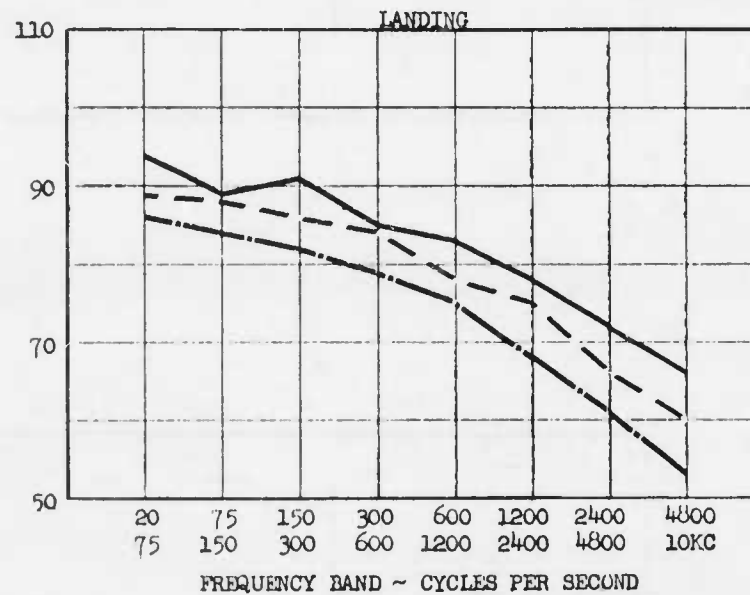
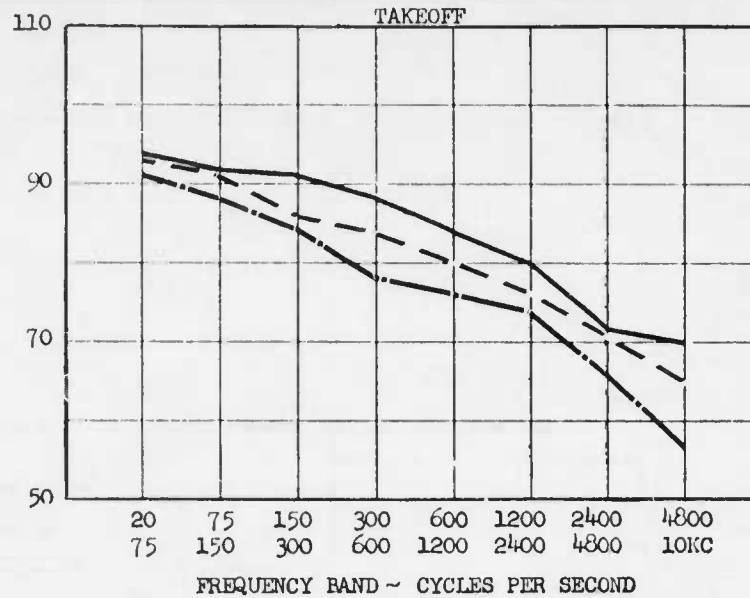
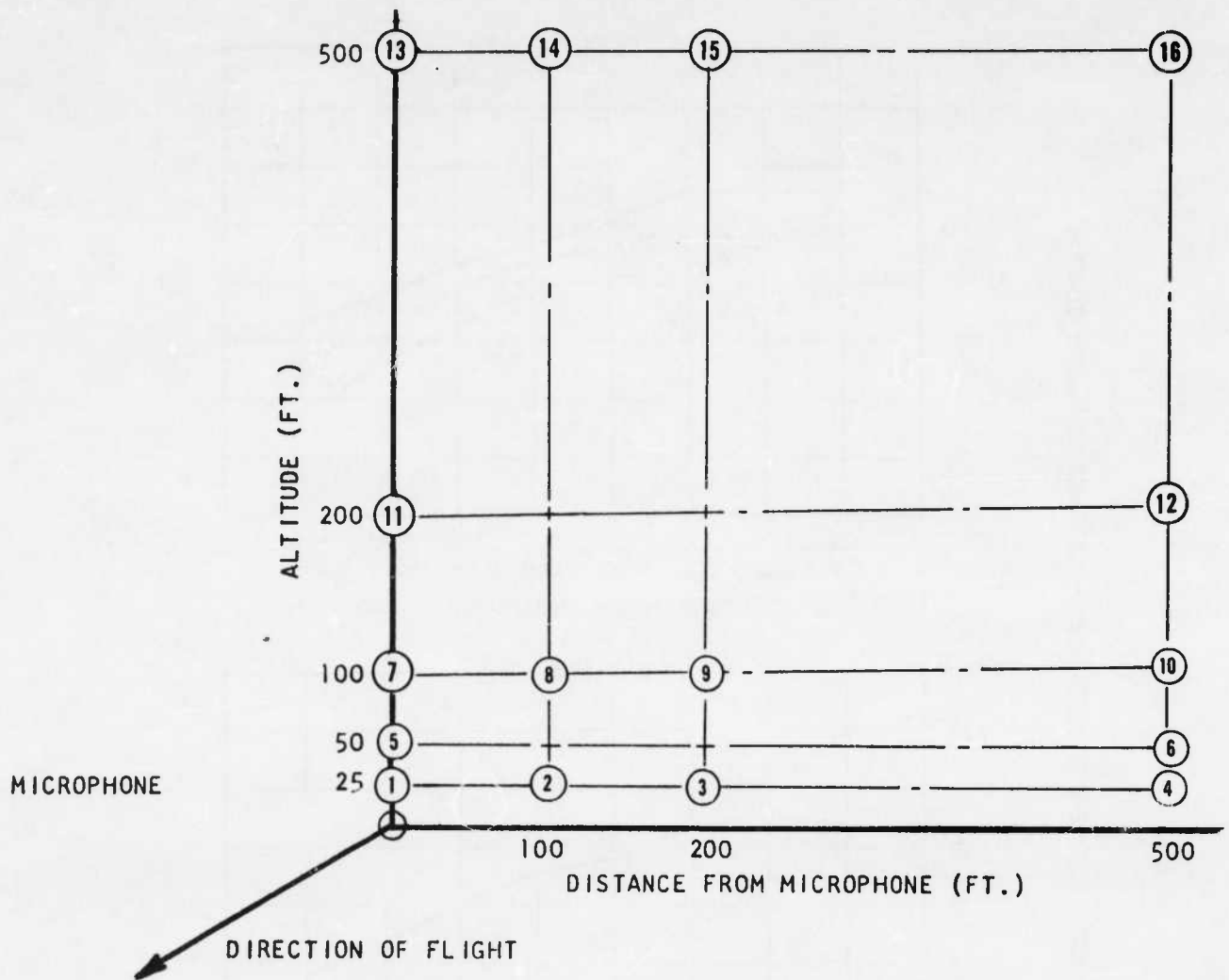


Figure 6



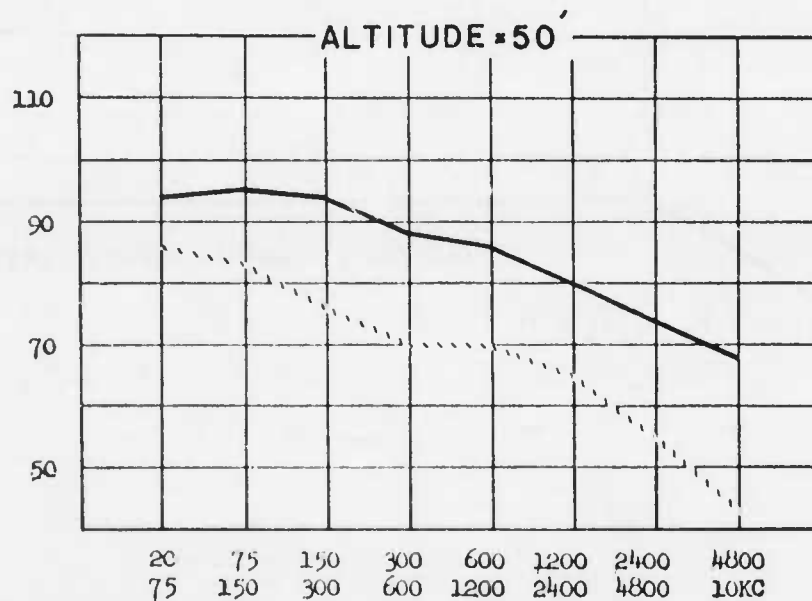
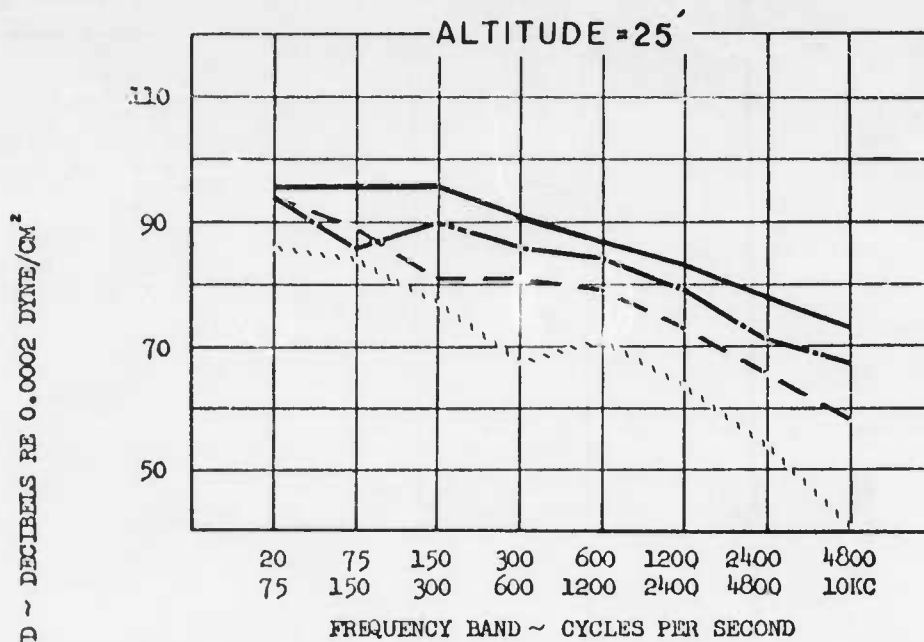
MEASUREMENT LOCATIONS - TEST 3

FIGURE 7

# MAXIMUM EXTERNAL SOUND PRESSURE LEVELS MEASURED AT GROUND STATION

A/C-TEST

HU-1A-3



## DISTANCES

0' —————  
 100' - - - - -  
 200' - . . . . .  
 500' ·······

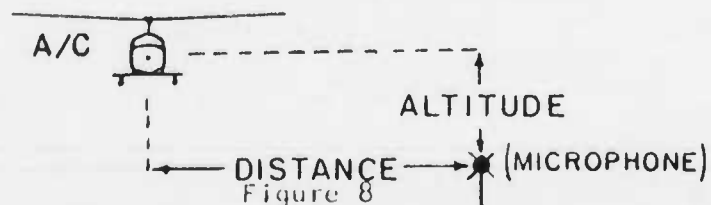


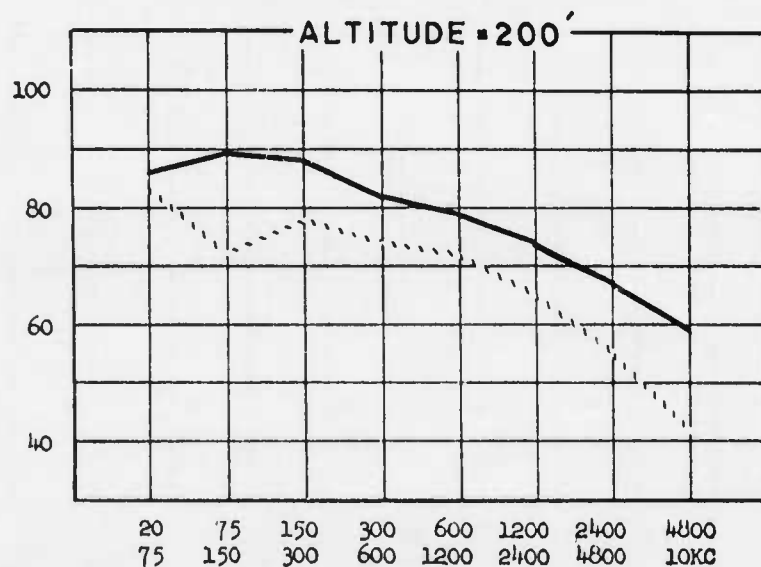
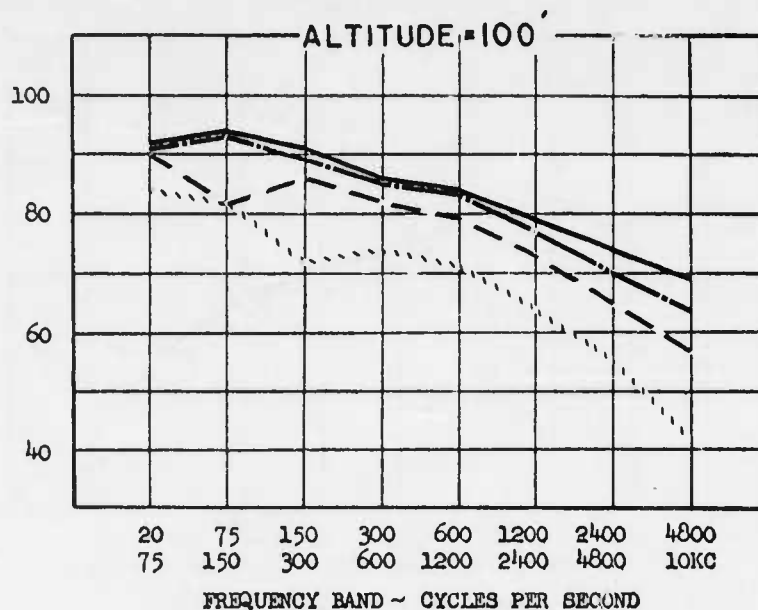
Figure 8

# MAXIMUM EXTERNAL SOUND PRESSURE LEVELS MEASURED AT GROUND STATION

A/C-TEST

HU-1A-3

SOUND PRESSURE LEVEL IN BAND ~ DECIBELS RE 0.0002 DYNE/CM<sup>2</sup>



## DISTANCES

0' —————  
 100' - - - - -  
 200' - - - - -  
 500' ·······

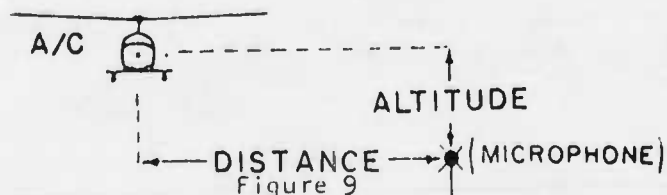
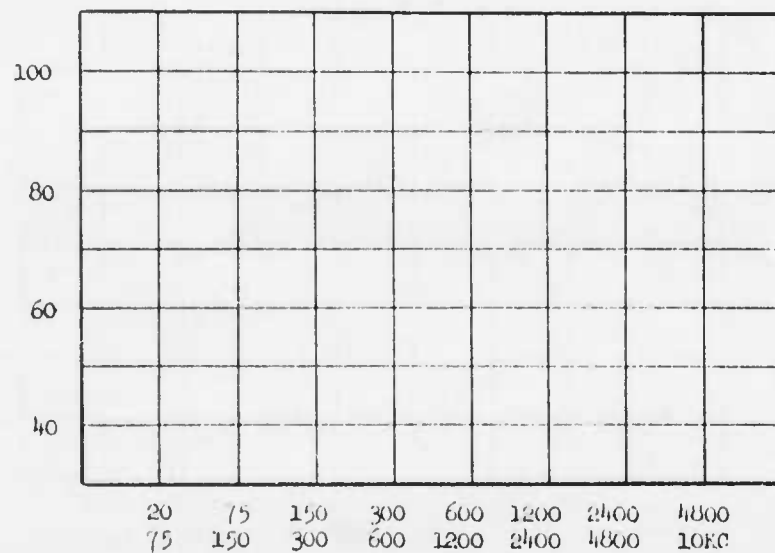
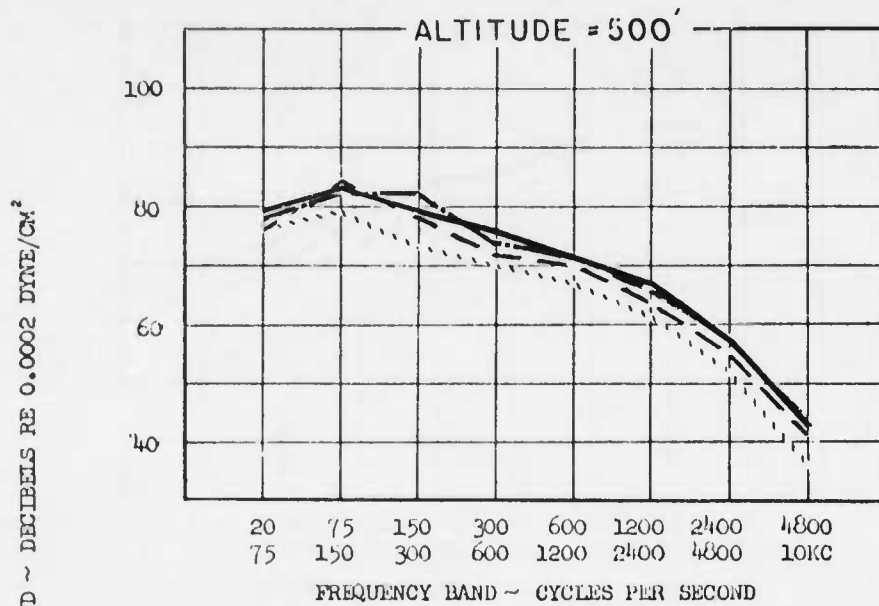


Figure 9

# MAXIMUM EXTERNAL SOUND PRESSURE LEVELS MEASURED AT GROUND STATION

A/C - TEST

HU-1A-3



## DISTANCES

0' —————  
100' - - - - -  
200' - - - - -  
500' ·······

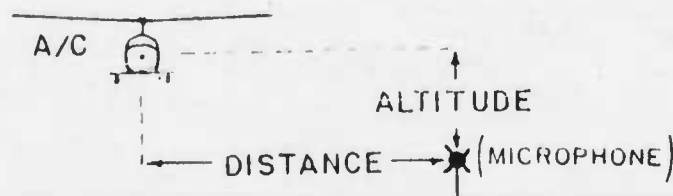
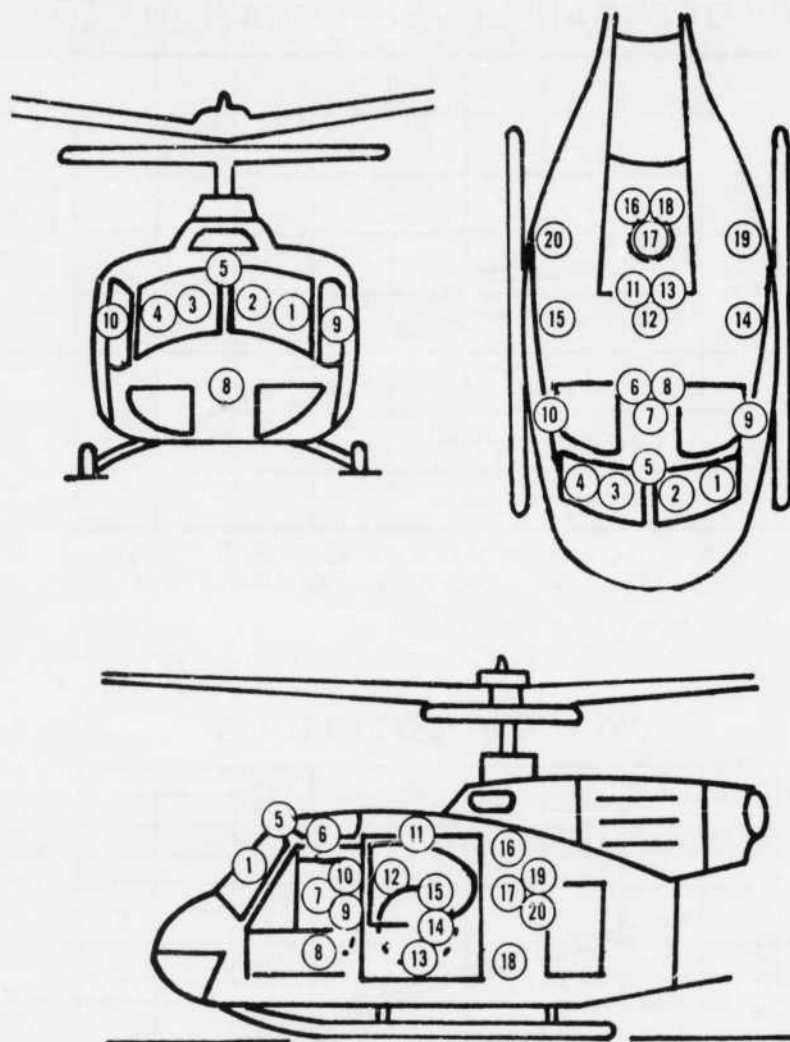


Figure 10

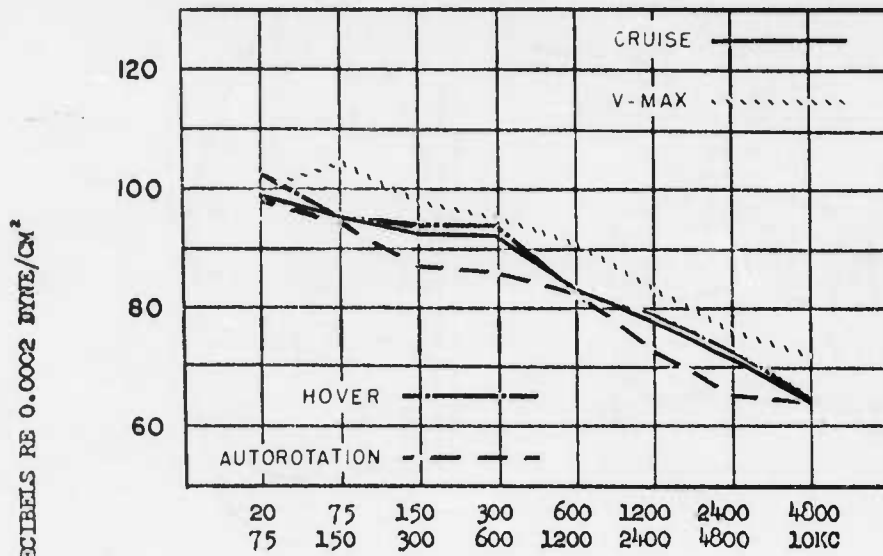




APPROXIMATE MICROPHONE POSITIONS USED FOR  
VARIOUS NOISE MEASUREMENTS INSIDE AIRCRAFT

FIGURE 11

## PILOT'S EAR LEVEL LOCATION (7)



## WINDOW LOCATIONS

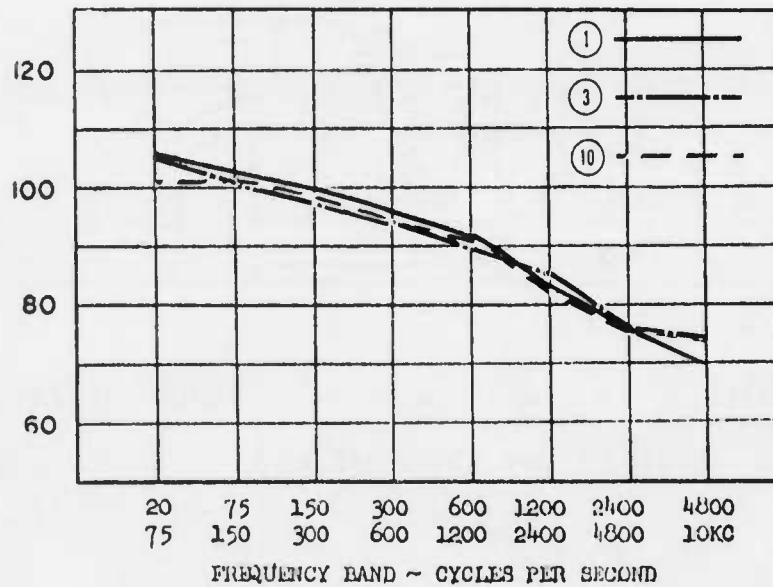


Figure 12

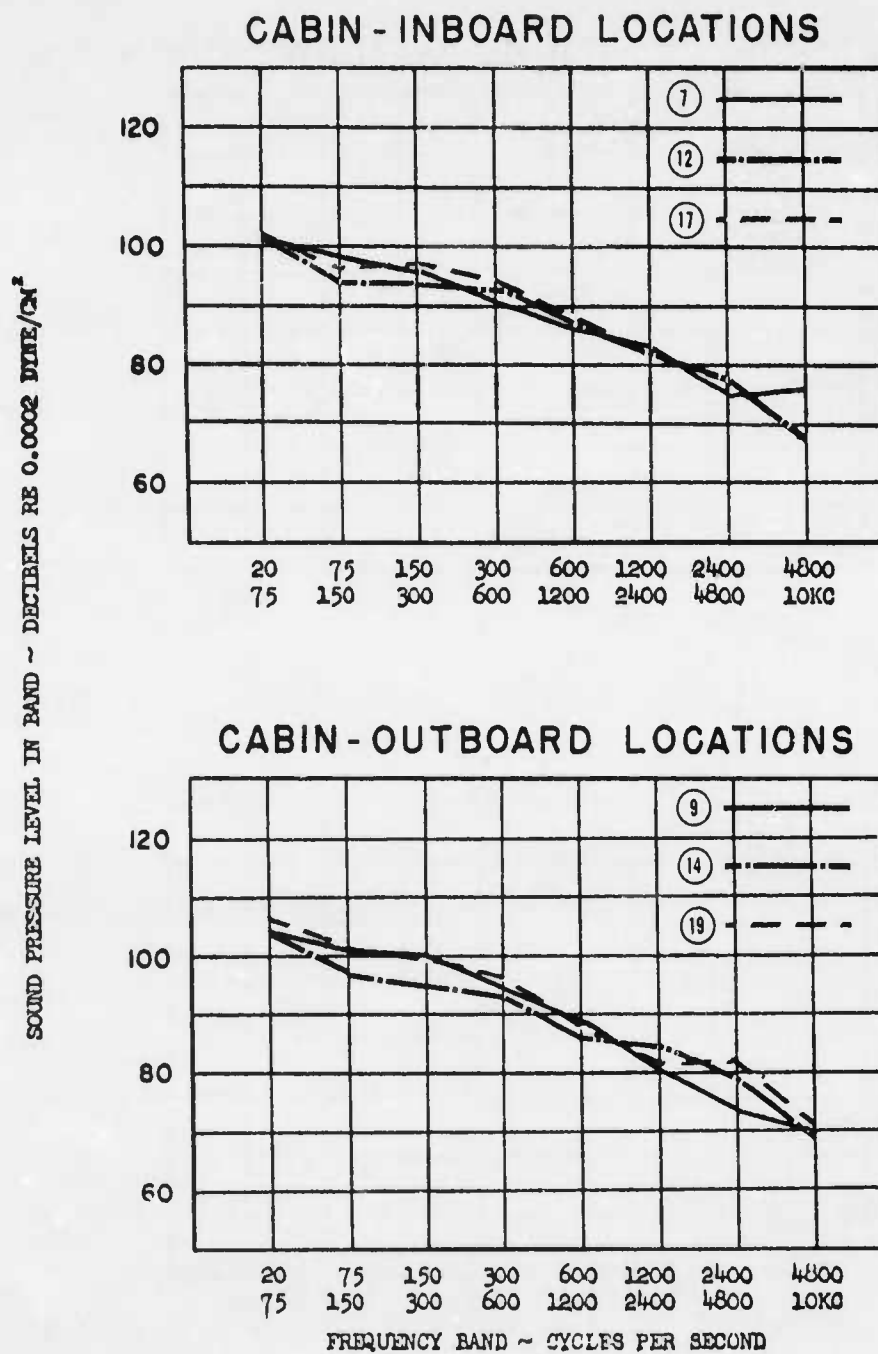


Figure 13

A/C-TEST

HU-1A-4

# VARIOUS LOCATIONS-WINDOWS OPEN

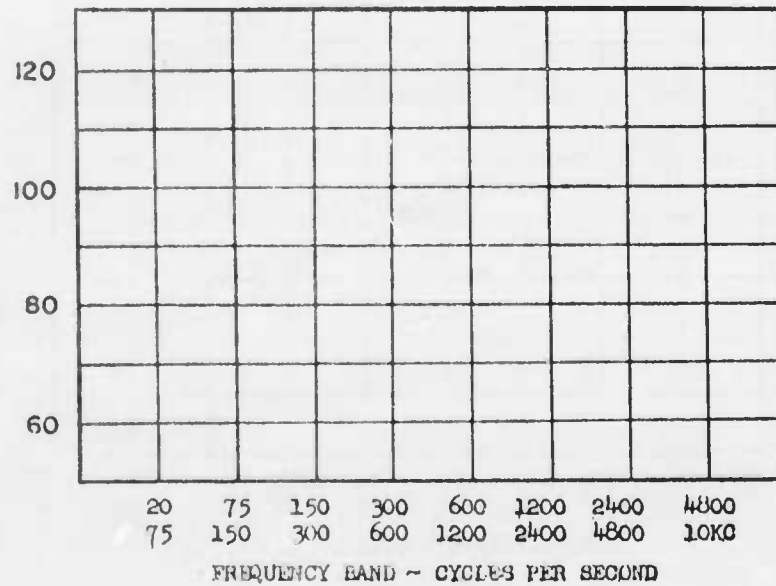
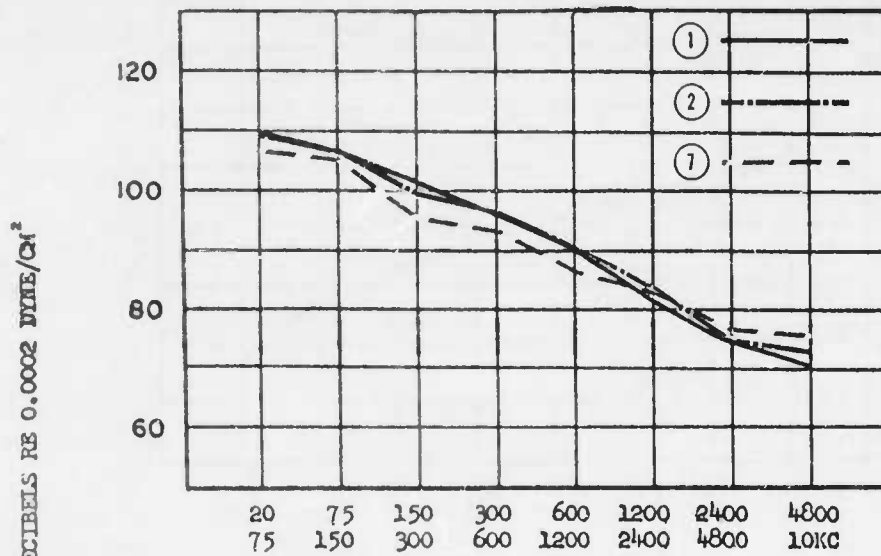


Figure 14

# HU-1A NOISE SPECTRUM POSITION 7 PILOT'S EAR LEVEL

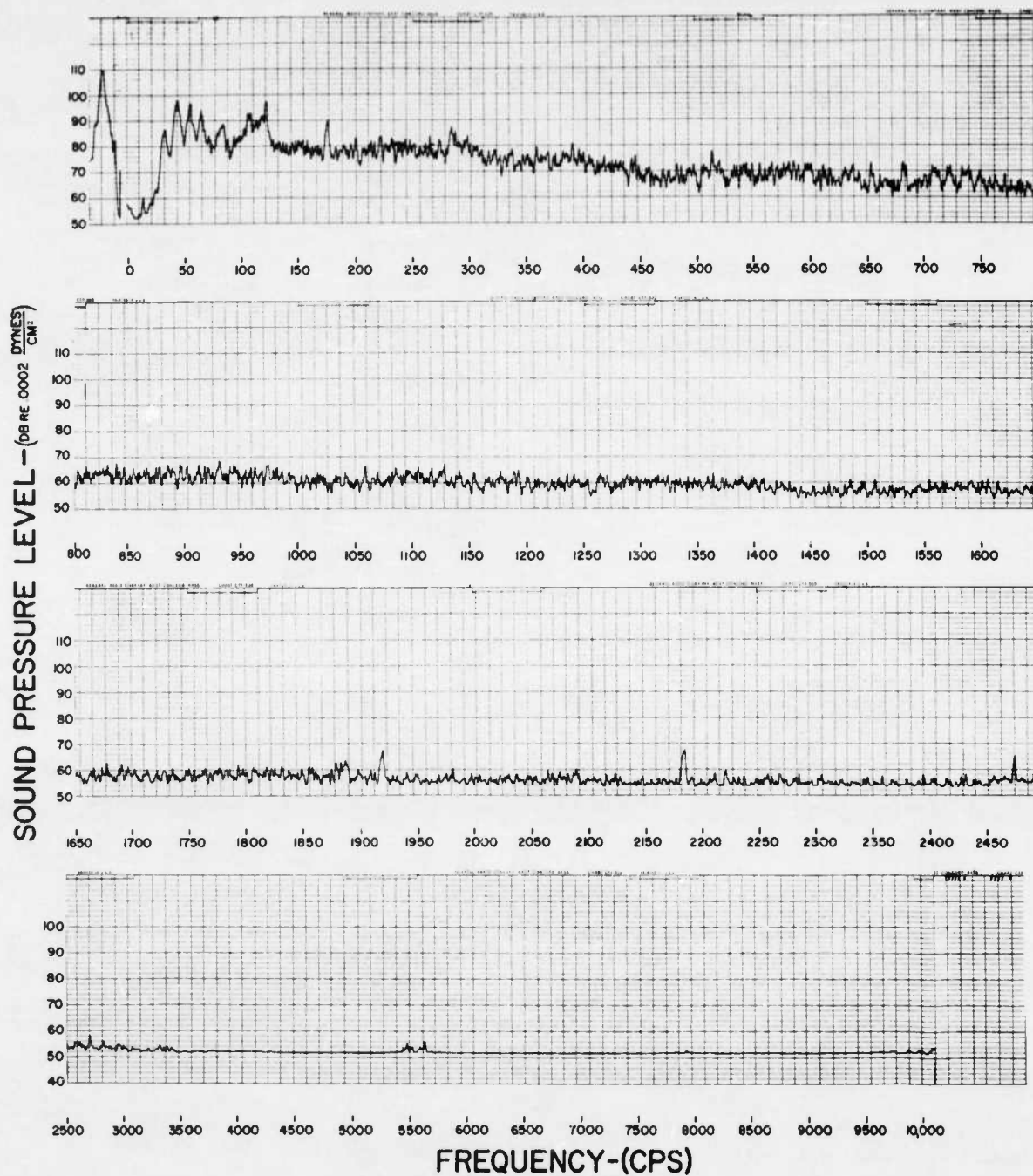


FIGURE 15

# HU-1A NOISE SPECTRUM

POSITION 19 CABIN

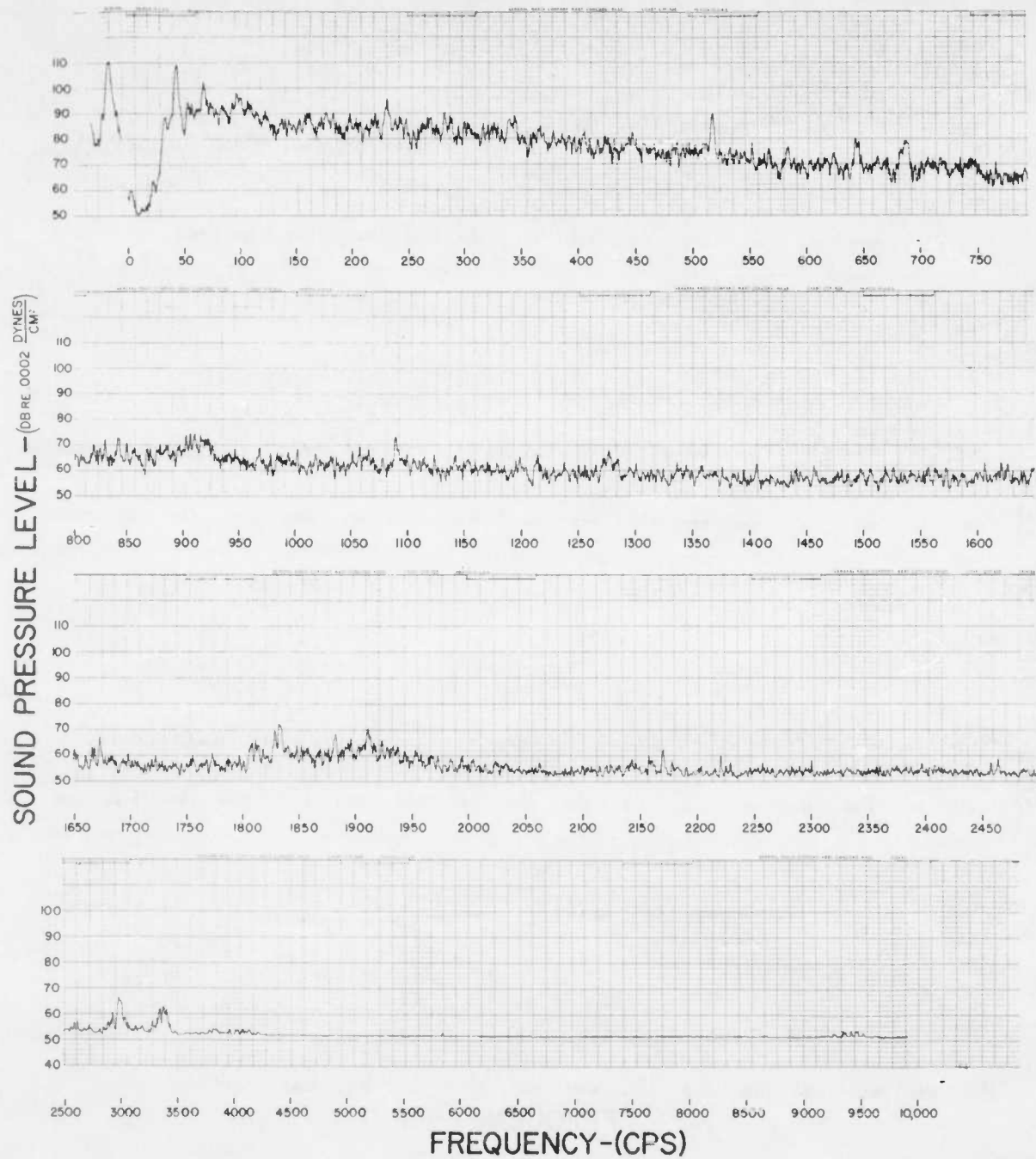


FIGURE 16

# HU-1A NOISE SPECTRUM

POSITION 23 EXTERNAL

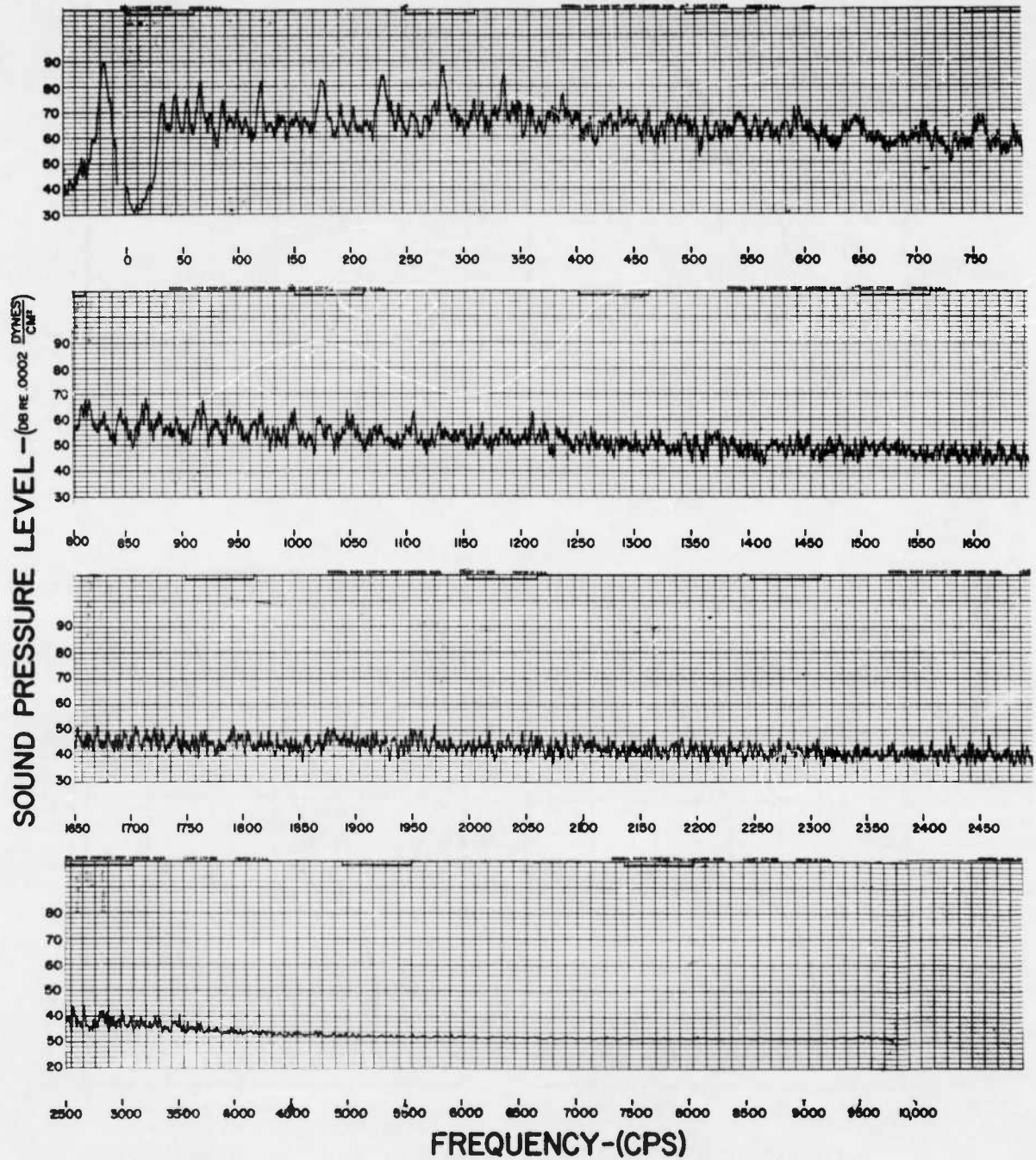


FIGURE 17

COMPARISON OF  
EXTERNAL SOUND PRESSURE LEVELS  
AT 200 FT. RADIUS

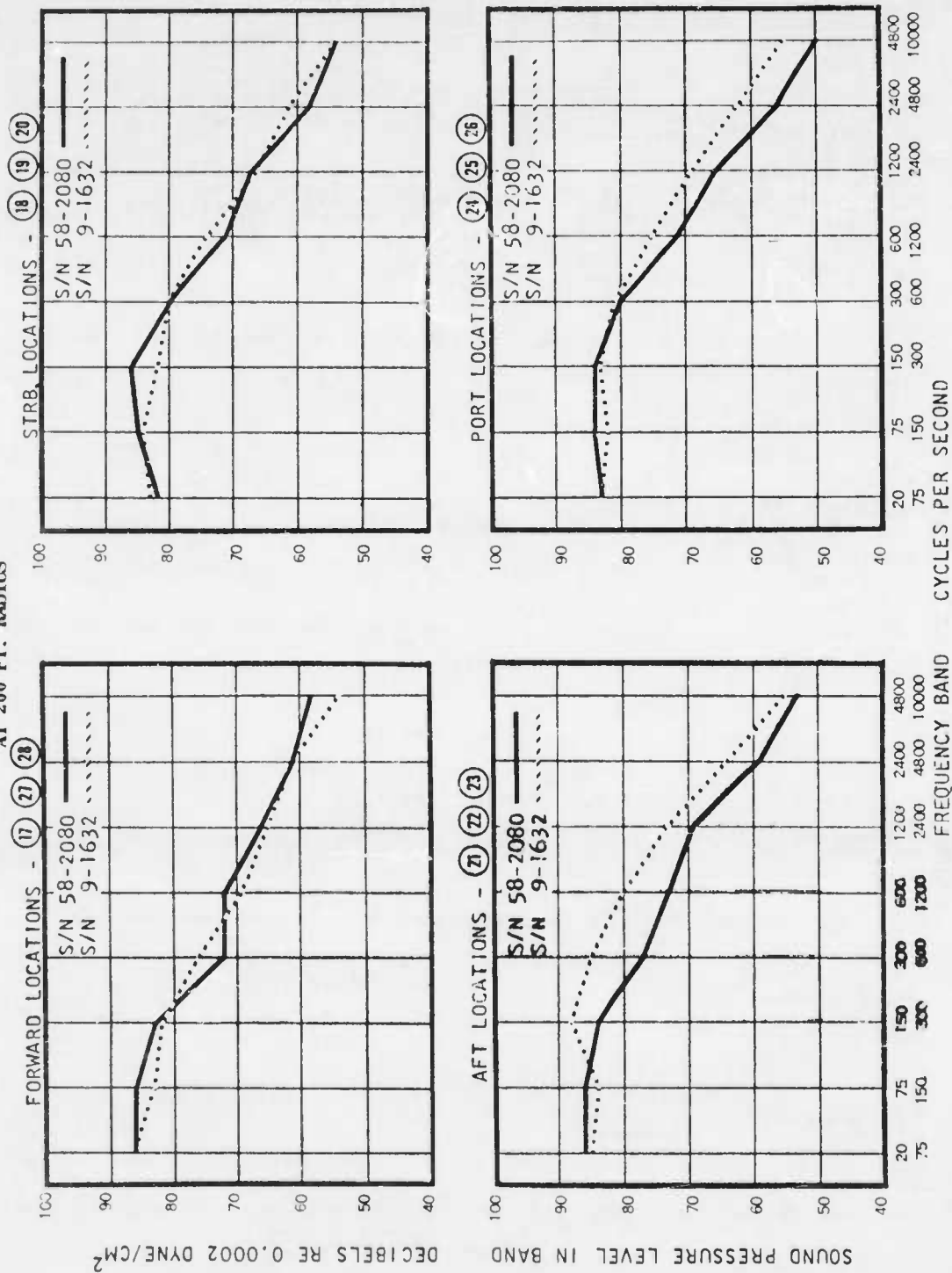


FIGURE 18

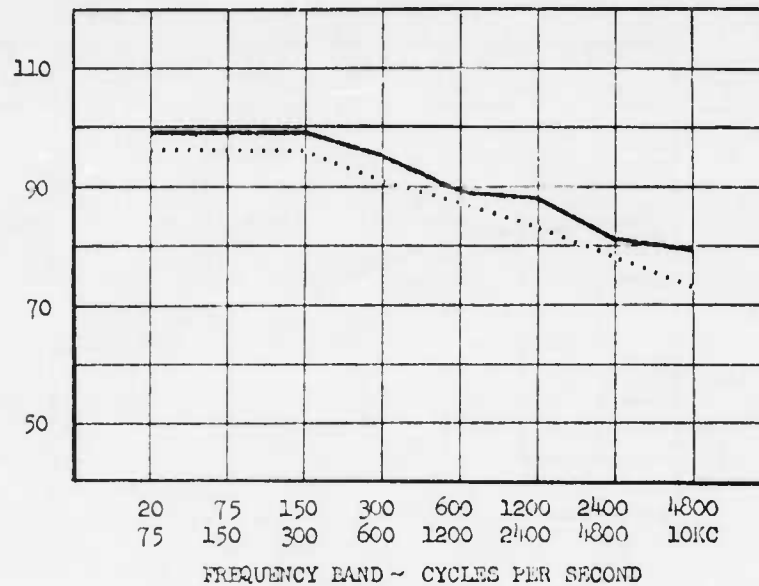


# COMPARISON OF OVERHEAD FLYBYS

Measurement Location Directly Under Aircraft

S/N 58-2080 ..... S/N 9-1632 ———

ALTITUDE 25 FT.



ALTITUDE 50 FT.

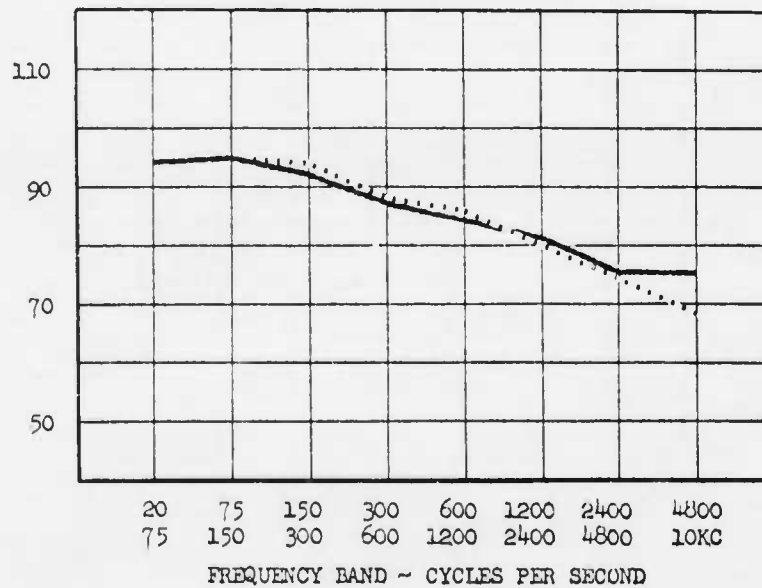


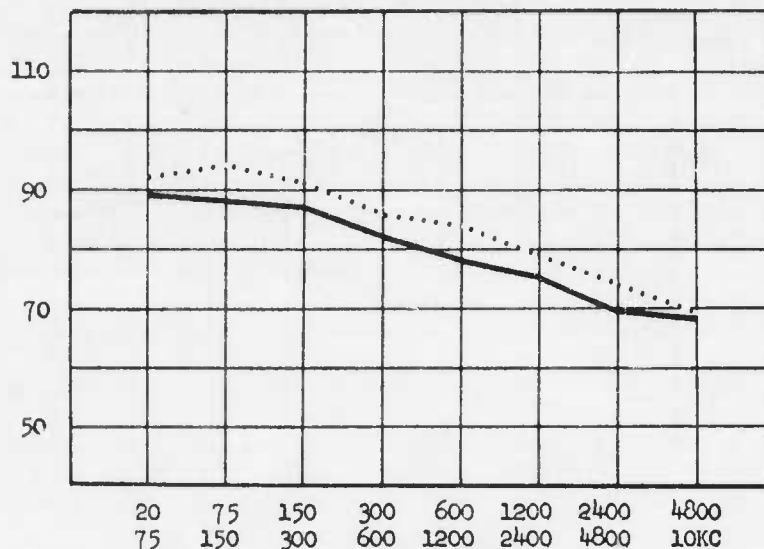
FIGURE 19

# COMPARISON OF OVERHEAD FLYBYS

Measurement Location Directly Under Aircraft

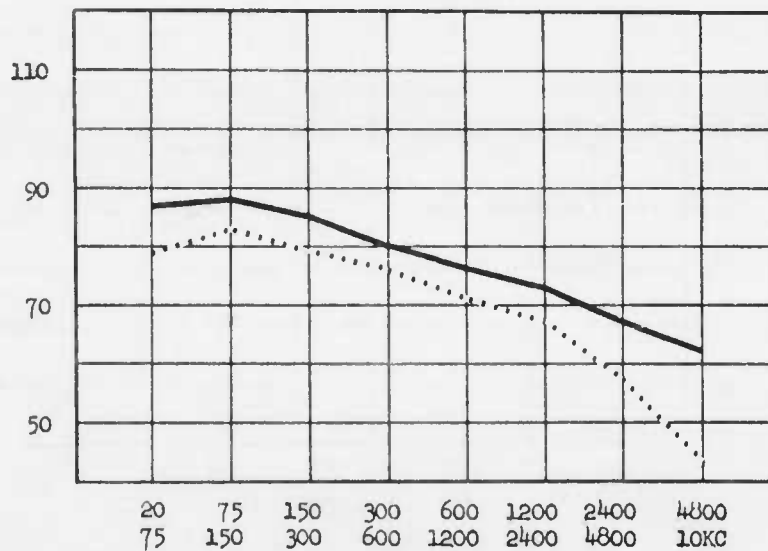
S/N 58-2080 ..... S/N 9-1632 ———

ALTITUDE 100 FT.



FREQUENCY BAND ~ CYCLES PER SECOND

ALTITUDE 500 FT.



FREQUENCY BAND ~ CYCLES PER SECOND

FIGURE 20

# IDENTIFICATION OF NOISE SOURCES

HU-1A

EXTERNAL POSITION 23

S/N 58-2080

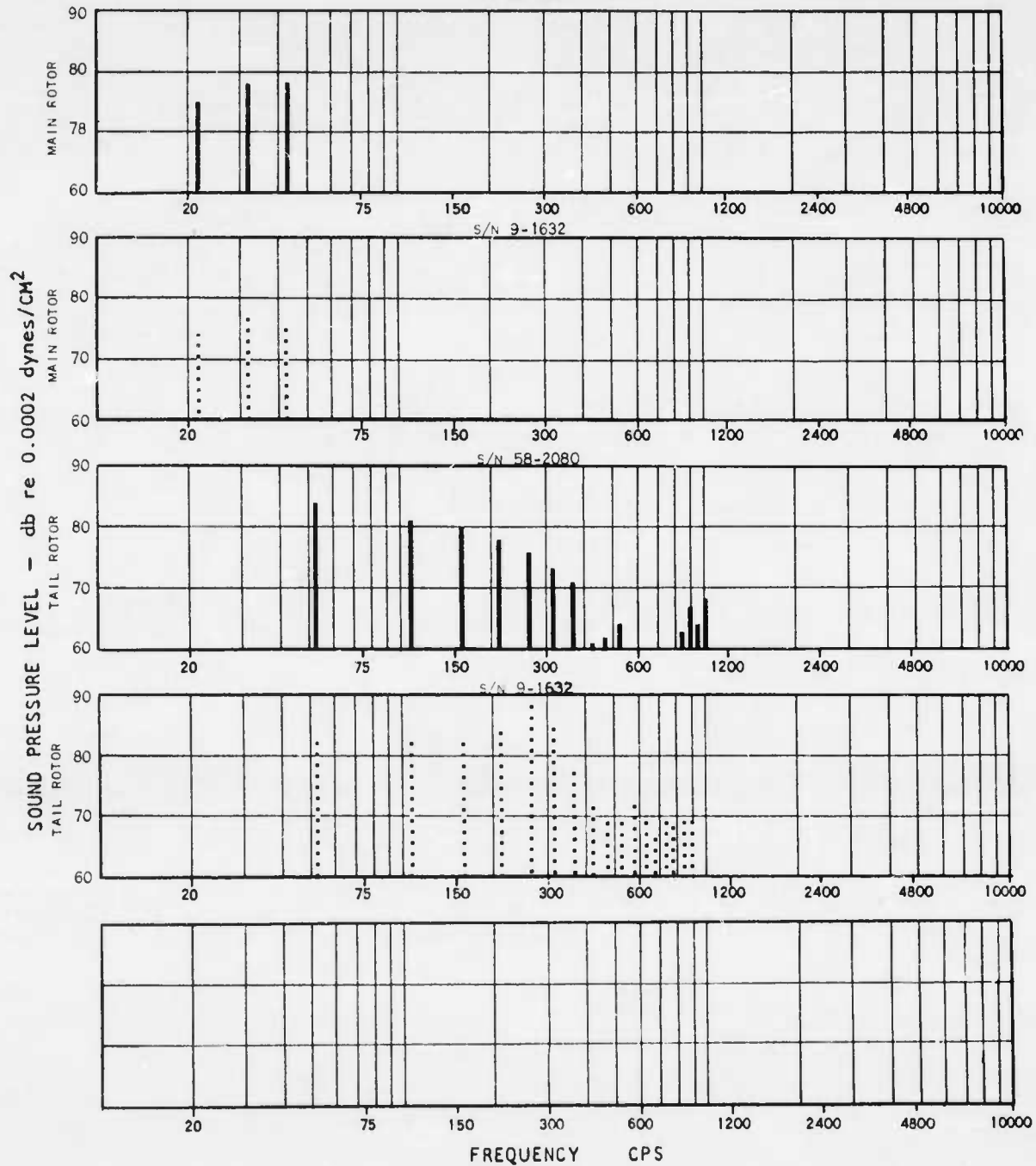


FIGURE 21

APPENDIX II  
DATA SHEETS

A/C - TEST  
HU-1A-1

# OCTAVE-BAND ANALYSIS SHEET

Analyzed By \_\_\_\_\_ DATE \_\_\_\_\_

LOC.	COND.		Ocatve-Band Pressure Levels Re. .0002 microbar							
			20- 75	75- 150	150- 300	300- 600	600- 1200	1200- 2400	2400- 4800	above 4800
1	HOVER		96	90	90	86	82	75	68	64
2	HOVER		100	94	94	87	84	78	70	65
3	HOVER		100	98	100	92	90	84	76	68
4	HOVER		98	98	101	96	92	76	76	69
5	HOVER		99	94	94	87	86	72	70	65
6	HOVER		101	96	92	85	82	70	71	62
7	HOVER		99	93	95	90	88	83	73	67
8	HOVER		98	94	96	94	88	82	73	68
9	HOVER		96	92	94	93	86	80	71	65
10	HOVER		95	90	94	91	85	78	70	66
11	HOVER		98	96	92	86	83	75	70	65
12	HOVER		98	94	90	86	78	73	67	64
13	HOVER		106	102	99	100	95	90	80	75
14	HOVER		103	101	98	96	92	88	82	74
15	HOVER		101	98	101	97	95	93	80	75
16	HOVER		106	98	96	95	90	83	76	73
17	HOVER		85	78	81	76	67	63	60	53
18	HOVER		84	80	79	74	68	61	58	53

REV

A/C - TEST  
HU-1A-1

# OCTAVE-BAND ANALYSIS SHEET

ANALYZED BY \_\_\_\_\_ DATE \_\_\_\_\_

[illegible]

A/C - TEST  
HU-1A-2

### OCTAVE-BAND ANALYSIS SHEET

Analyzed By \_\_\_\_\_ DATE \_\_\_\_\_

[illegible]

A/C - TEST  
HU-1A-3

OCTAVE-BAND ANALYSIS SHEET

Analyzed By \_\_\_\_\_ DATE \_\_\_\_\_

LOC.	COND.		Octave-Band Pressure Levels Re. .0002 microbar							
			20- 75	75- 150	150- 300	300- 600	600- 1200	1200- 2400	2400- 4800	above 4800
1	CRUISE		96	96	96	91	87	83	78	73
2	CRUISE		94	86	90	86	84	79	71	67
3	CRUISE		94	89	81	81	79	73	66	58
4	CRUISE		86	84	77	68	71	64	54	41
5	CRUISE		94	95	94	88	86	80	74	68
6	CRUISE		86	83	76	70	70	65	55	43
7	CRUISE		92	94	91	86	84	79	74	69
8	CRUISE		91	93	89	85	83	77	70	64
9	CRUISE		90	82	86	82	79	73	65	57
10	CRUISE		84	82	72	74	71	64	55	42
11	CRUISE		86	89	88	82	79	74	67	59
12	CRUISE		83	74	78	74	72	65	55	42
13	CRUISE		79	83	73	71	71	67	57	43
14	CRUISE		78	82	82	74	71	66	58	44
15	CRUISE		76	84	78	72	70	64	55	41
16	CRUISE		76	79	73	70	67	61	52	36

REV



A/C - TEST  
HU-1A-4

# OCTAVE-BAND ANALYSIS SHEET

Analyzed By \_\_\_\_\_ DATE \_\_\_\_\_

LOC.	COND.		Octave-Band Pressure Levels Re. .0002 microbar							
			20-75	75-150	150-300	300-600	600-1200	1200-2400	2400-4800	above 4800
1	CRUISE		106	103	100	96	91	82	75	70
2	CRUISE		106	101	98	96	90	83	75	71
3	CRUISE		105	101	97	95	90	85	75	74
4	CRUISE		102	100	97	94	88	80	75	74
5	CRUISE		105	102	101	98	92	85	75	71
6	CRUISE		103	100	98	93	88	82	75	71
7	CRUISE		101	99	96	91	86	83	75	76
8	CRUISE		99	96	97	92	86	82	74	72
9	CRUISE		104	101	100	94	89	81	74	70
10	CRUISE		101	101	99	94	91	82	75	74
11	CRUISE		101	96	96	96	91	83	76	67
12	CRUISE		102	94	94	92	87	82	78	68
13	CRUISE		101	97	95	93	87	82	77	69
14	CRUISE		104	98	95	93	86	84	79	69
15	CRUISE		103	100	97	97	89	83	79	72
16	CRUISE		102	97	98	98	92	88	78	66
17	CRUISE		102	97	97	95	89	82	78	67
18	CRUISE		104	99	98	94	89	83	76	68

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